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Nivicolous myxomycetes from the Navarran and French Pyrenees

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Abstract—Twenty-six collections of myxomycetes are reported from localities in northern Spain and southern France, representing nine species: *Diderma alpinum*, *D. europaeum*, *D. fallax*, *D. meyerae*, *Lamproderma ovoideum*, *L. sauteri*, *Lepidoderma peyerimhoffii*, *Meriderma echinulatum*, and *Physarum vernum*. The LM and SEM micrographs included illustrate the most representative characters of each species.

Key words—*Amoebozoa,* myxobiota, *Myxogastria*, slime moulds, taxonomy

Introduction

Different species of nivicolous myxomycetes are described herein. These were collected in northern Spain in Belagua Valley (also known as Roncal Valley) in the north-western part of the Pyrenees; and in southern France at La Pierre San Martín ski resort in the French continuation of the Roncal Valley (Fig. 1).

The Spanish area is covered by a beech–fir forest accompanied by *Pinus uncinata* Ramond ex DC., *Rhododendron ferrugineum* L., *Vaccinium myrtillus* L., and *Juniperus communis* var. *alpina* Gaudin. The sampling elevation varied from 1700 to 2000 m, while the French samples were collected at 1500 to 2200 m.

FIG. 1 The study area covered during the research.

The diversity of nivicolous myxomycetes in these areas is poorly known, and all collections presented here constitute new records for both locations.

Materials & methods

The material studied and the slides mounted in Hoyer's medium for each specimen are preserved in the herbarium of the Universidad de Alcalá, Alcalá de Henares, Madrid, Spain (AH).

Spore measurements were made using an oil immersion objective and include surface structures such as warts and spines.

Scanning electron microscopy (SEM) micrographs were obtained at the Universidad de Alcalá using a Zeiss DSM-950. For ultramicroscopic studies, one sporocarp was placed on a 2 × 2 cm square of Whatman filter paper no. 2; the paper was folded into a packet to prevent the loss of spores and stapled shut, after which the packeted specimen was rehydrated in concentrated ammonium hydroxide (28–30%) for 30 minutes, dehydrated in aqueous ethanol (70%) for 30 minutes, fixed for two hours in pure ethylene glycol dimethyl ether (= 1,2-dimethoxymethane), immersed in pure acetone for at least two hours, and finally critically point dried and sputtered with gold-palladium. This technique uses very little material (a portion of a single sporocarp or no more than a few spores).

Taxonomy

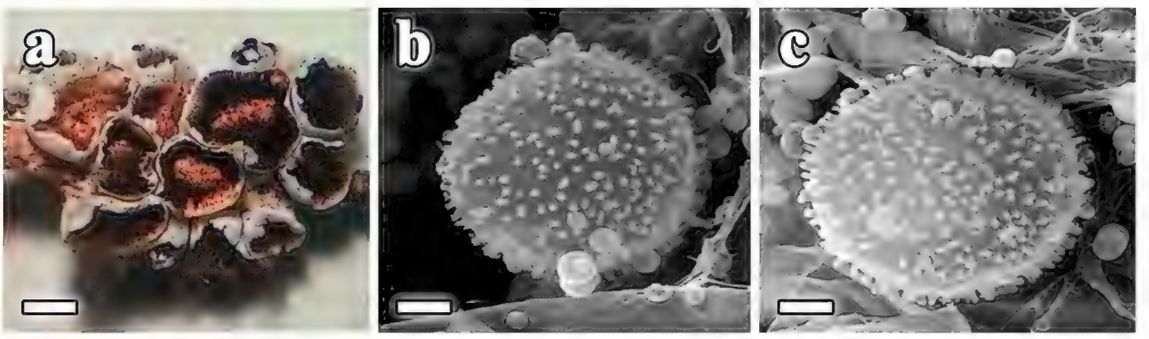

Fig. 2 *Diderma alpinum* (AH 50407): a. Sporocarps; b. Spore; c. Spore ornamentation (detail). Scale bars: a = 1 mm; b, c = 2 μm.

Diderma alpinum (Meyl.) Meyl., Bull. Soc. Vaud. Sci. Nat. 51: 261. 1917 Fig. 2

The capillitium of the specimens is hyaline to slightly grey under the stereomicroscope, the pseudocolumella is prominent and orange, and the spore ornamentation consists of abundant and regularly distributed spines.

Specimens examined: **FRANCE, Pyrénées-Atlantiques, Arette,** La Pierre San Martín ski resort, herbaceous debris, 26–v–2018, leg. M. Tapia 180526–020 (AH 50407); **SPAIN, Navarra, Isaba,** Belagua Valley, woody debris, 8–v–2018, leg. M. Tapia 180508–039 (AH 50410); on *Erica* sp. woody debris, 8–v–2018, leg. M. Tapia 180508–025 (AH 50416).

Remarks—The aforementioned characters are typical among Spanish collections of *Diderma alpinum*. Nonetheless, Kuhnt (2009) described it as a plasmodiocarpic species and reported it as such in his photographs. Future molecular studies are needed to disentangle the complex involving *D. alpinum*, *D. niveum* (Rostaf.) E. Sheld., *D. microcarpum* Meyl., and other closely related species.

Diderma alpinum is a common species in the Northern Hemisphere (https://www.gbif.org).

Diderma europaeum (Buyck) Kuhnt, Ber. Bayer. Bot. Ges. 87: 111. 2017 Fig. 3

The two examined specimens are representative of the species due to their globose to subglobose and clustered to (rarely) scattered sporocarps, sometimes with remains of a whitish hypothallus. Peridium double, externally white. Capillitium hyaline, emerging radially from the pseudocolumella. Pseudocolumella white, prominent, with warts on the surface. Spores violaceous-brown, globose to subglobose, 11–12 μm in diam., spinose.

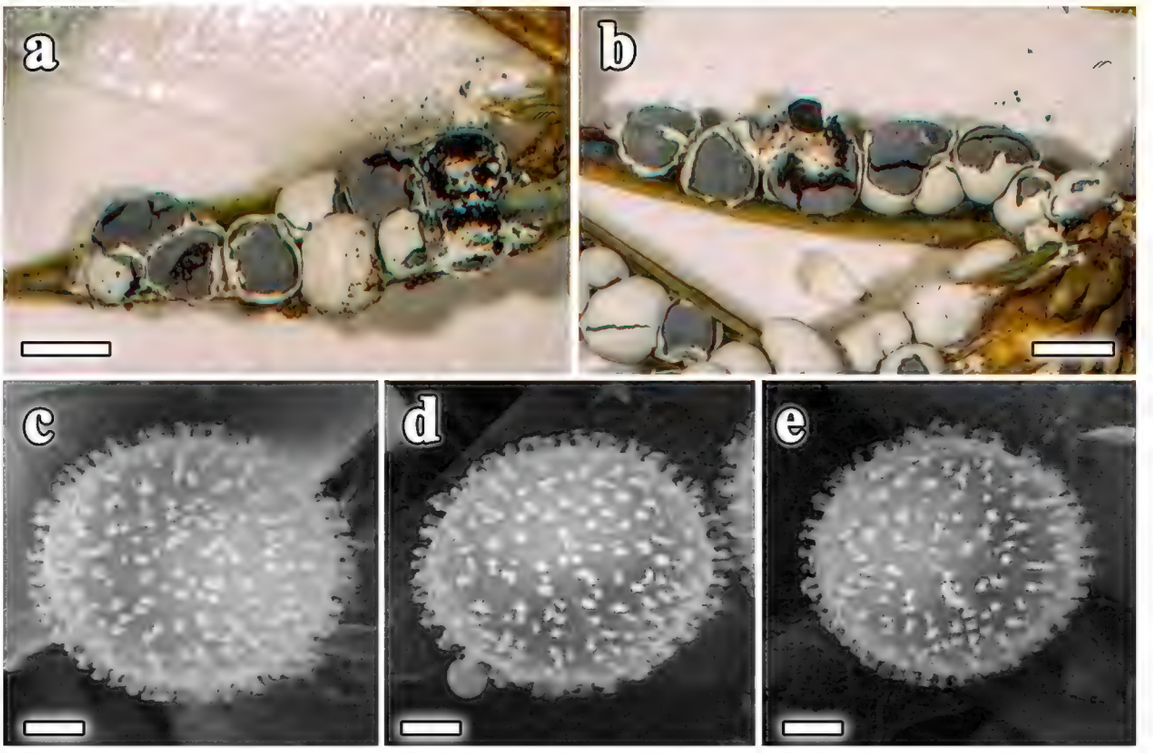

Fig. 3 *Diderma europaeum* (AH 50414): a, b. Sporocarps; c–e. Spores. Scale bars: a, b = 1 mm; c–e = 2 µm.

Specimens examined: **SPAIN, Navarra, Isaba,** Belagua Valley, *Juniperus communis* var. *alpina* leaves, 8-v-2018, leg. M. Tapia 180508-032 (AH 50414); on twigs, 10-vi-2018, leg. M. Tapia 180610-043 (AH 50497).

Remarks—A representative photograph of *Diderma europaeum* can be found in Poulain & al. (2011). This species has been widely cited, especially in Central Europe and northern Spain (https://www.gbif.org).

Diderma fallax (Rostaf.) E. Sheld., Minnesota Bot. Stud. 1: 477. 1895 Fig. 4

The specimens examined are characterized by clustered sporocarps, a double peridium, and a prominent, club-shaped pseudocolumella. The outer peridium breaks easily in polygonal plates, allowing the inner, membranous peridium to be visible. On the inner peridium, remains of globular crystals from the outer peridium can be observed. Capillitium with abundant, radial threads, black colored, and with nodules (3–5 µm diam.) visible under transmitted light. Spores dark violaceous-brown under transmitted light, globose to subglobose, 14–16 µm in diam., spinose. Under SEM, the spore ornamentation is seen as lax, irregularly distributed spines, occasionally with coralloid tips.

The peridium in AH 50402 is decarbonated, although the globular crystals of calcium carbonate can be observed under transmitted light.

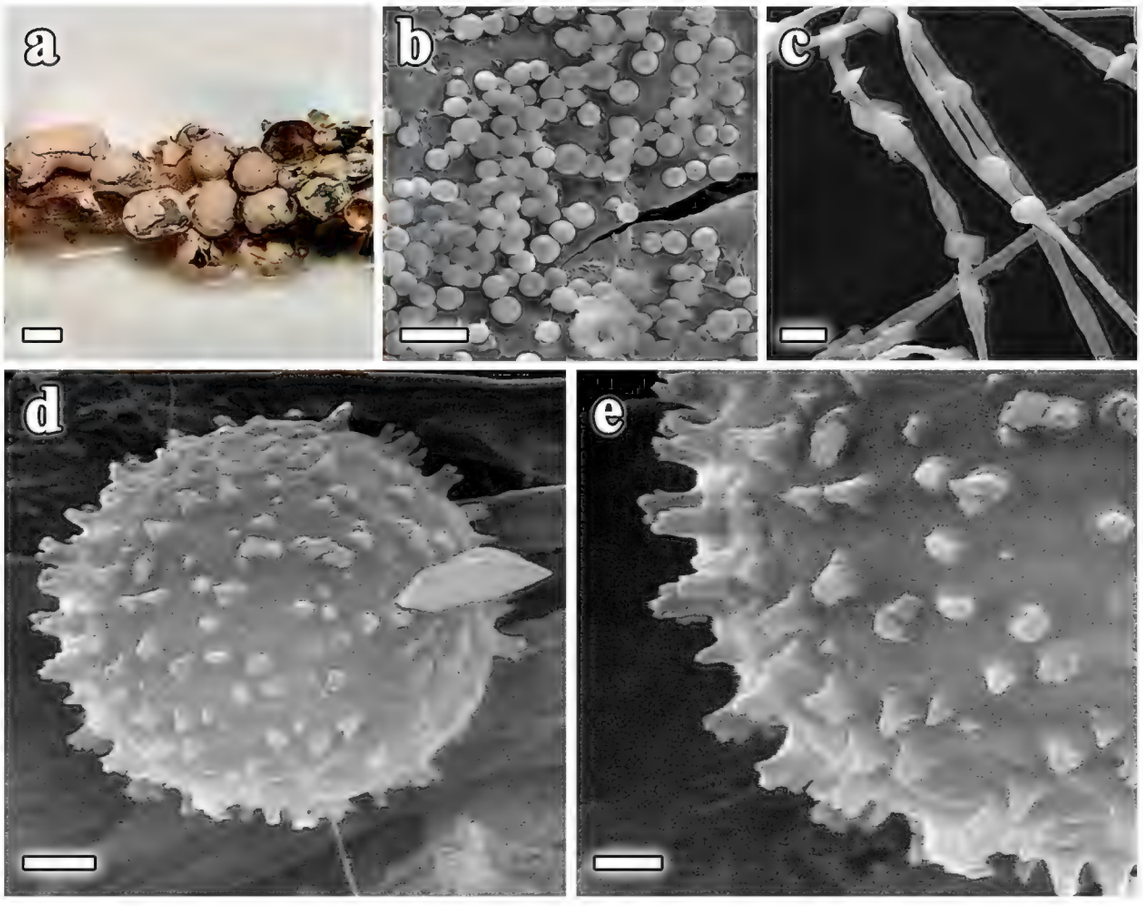

Fig. 4 *Diderma fallax* (AH 50403): a. Sporocarps; b. Inner peridium with globular crystals of calcium carbonate; c. Capillitium; d. Spore; e. Spore ornamentation (detail). Scale bars: a = 1 mm; b, c = 5 µm; d = 2 µm; e = 1 µm.

Specimens examined: **FRANCE, Pyrénées-Atlantiques, Arette,** La Pierre San Martín ski resort, herbaceous debris, 26-v-2018, leg. M. Tapia 180526-017 (AH 50403); leg. M. Tapia 180526-011 (AH 50402); **SPAIN, Navarra, Isaba,** Belagua Valley, herbaceous debris, 8-v-2018, leg. M. Tapia 180508-035 (AH 50413); 15-vi-2018, leg. M. Tapia 180615-001 (AH 50499).

Remarks—*Diderma fallax* has been widely confused with similar species of *Lepidoderma* de Bary, including *L. peyerimhoffii, L. nevadense* G. Moreno & al., and *L. echinosporum* G. Moreno & al. The taxonomic treatment used herein follows Moreno & al. (2018b). *Diderma fallax* can be distinguished from any other *Lepidoderma* species, thanks to the globular calcium carbonate that forms the external peridium, absent in *Lepidoderma*.

Diderma meyerae H. Singer, G. Moreno, Illana & A. Sánchez, Cryptog. Mycol. 24(1): 53. 2003. Fig. 5

The specimens examined have whitish to creamy sporangia, clustered, with a double peridium, and a globose, prominent, verrucose, orange

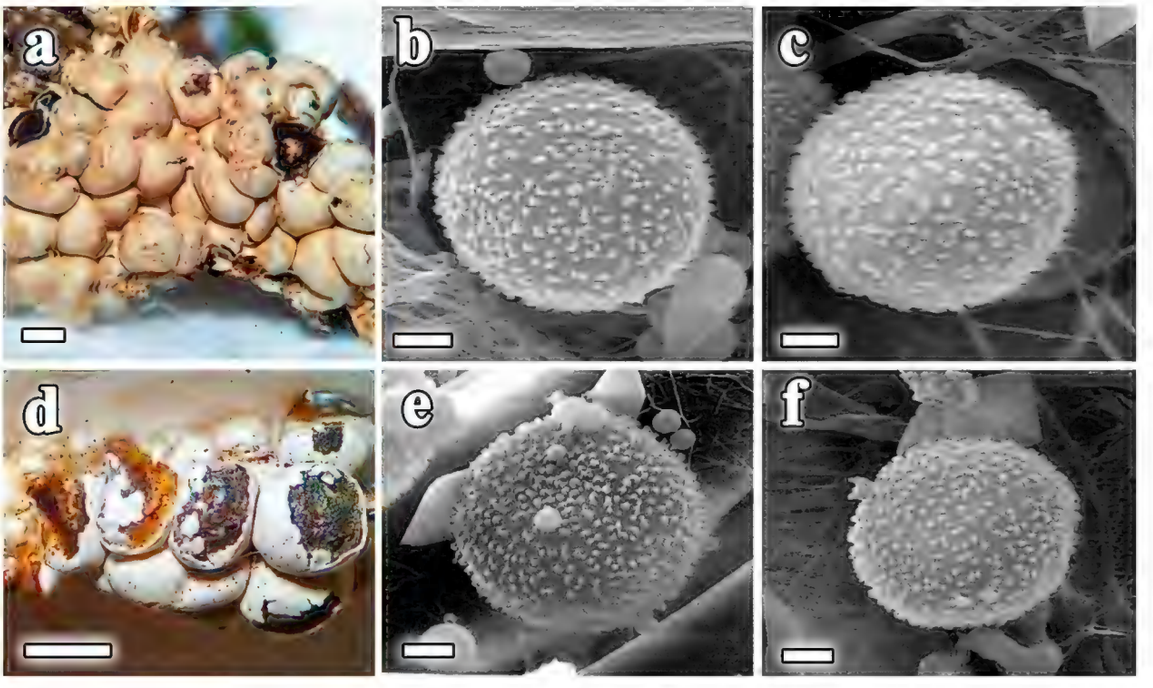

Fig. 5 *Diderma meyerae* (AH 50500 & AH 50502): a, d. Sporocarps; b, c, e, f. Spores. Scale bars: a, d = 1 mm; b, c, e, f = 2 µm.

pseudocolumella. Capillitium with blackish threads, emerging radially from the pseudocolumella. Spores violaceous-brown in transmitted light, globose to subglobose, 10–13 µm in diam., with thick warts. Under SEM, the ornamentation of the spores is also verrucose, but some short crests become apparent.

Specimens examined: **SPAIN, Navarra, Isaba,** Belagua Valley, herbaceous debris, 8-v-2018, leg. M. Tapia 180508-029 (AH 50408); 15-vi-2018, leg. M. Tapia 180615-010 (AH 50502); on *Erica* sp. leaves and inflorescences, 15-vi-2018, leg. M. Tapia 180615-003 (AH 50500); on vegetal debris and *Erica* sp. leaves, 15-vi-2018, leg. M. Tapia 180615-004 (AH 50501).

Remarks—The spore ornamentation consists of thick warts that sometimes join in low crests. This key character distinguishes *Diderma meyerae* from other morphologically similar species, such as *Diderma niveum* and *D. alpinum,* both of which develop bacula on their spores (Moreno & al. 2003).

Lamproderma ovoideum Meyl., Bull. Soc. Vaud. Sci. Nat. 57: 370. 1932 Fig. 6

Sporocarps short-stalked, grouped, 1.1–1.5 × 0.9–1.2 mm, with ovoid sporothecas. Capillitium brown, paler at the periphery, branched and anastomosed, not emerging radially from the columella. Spores dark brown with a paler area, globose to subglobose, 12–15 µm in diam., with very faint warts or spinules.

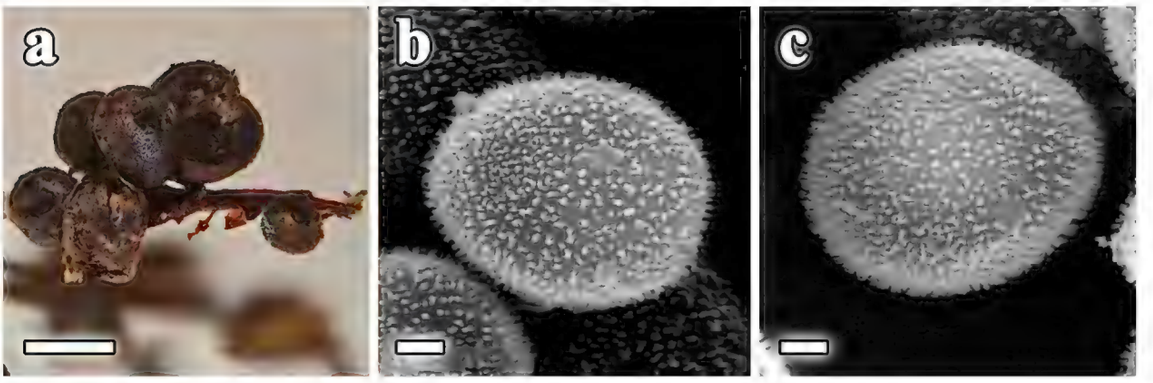

Fig. 6 *Lamproderma ovoideum* (AH 50415): a. Sporocarps; b, c. Spores. Scale bars: a = 1 mm; b, c = 2 µm.

Specimen examined: **SPAIN, Navarra, Isaba,** Belagua Valley, herbaceous debris, 8-v-2018, leg. M. Tapia 180508-027 (AH 50415).

Remarks—*Lamproderma ovoideum* is characterized by the ovoid sporotheca, short stalk, iridescent and blackish peridium, and 12–15 µm spores. *Lamproderma piriforme* (Meyl.) Mar. Mey. & Poulain can be distinguished by its larger (16–19.5 µm diam.) spores.

Lamproderma sauteri Rostaf., Sluzowce Monogr.: 205. 1874 Fig. 7

The specimens examined show crowded and stalked sporocarps, 1.5–2 × 0.7–1 mm. Stalk cylindrical, with length approximately the same as the diameter of the sporotheca (0.5–1 mm). Peridium membranous, violaceous-blue, iridescent. Capillitium emerging radially from the apex of the sporotheca, brown, paler in the periphery. Spores brown in transmitted light, globose to subglobose, 12–14 µm in diam., spinulose. Under SEM, the spore ornamentation consists of abundant and densely arranged bacula, occasionally creating short crests.

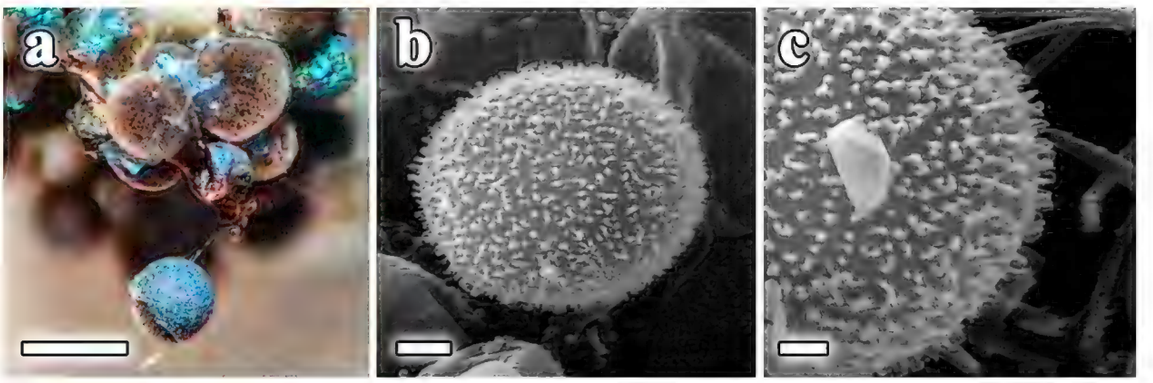

Fig. 7 *Lamproderma sauteri* (AH 50404): a. Sporocarps; b. Spore; c. Spore ornamentation (detail). Scale bars: a = 1 mm; b = 2 µm; c = 1 µm.

Specimens examined: **FRANCE, Pyrénées-Atlantiques, Arette,** La Pierre San Martín ski resort, on moss, 22-v-2018, leg. M. Tapia 180522-009 (AH 50495); **SPAIN, Navarra, Isaba,** Belagua Valley, on moss, 8-v-2018, leg. M. Tapia 180508-046 (AH 50404).

Remarks—*Lamproderma sauteri* can be confused with *Lamproderma splendidissimum* Mar. Mey. & al. and *Lamproderma splendens* Meyl. *Lamproderma splendidissimum* is characterized by the bright blue sporocarps, the shorter stalks (less than the height of the sporotheca), and the spinulose spores measuring 11–12 µm in diam. (Poulain & al. 2014). *Lamproderma splendens* can be easily distinguished from *Lamproderma sauteri* due to the verrucose spores.

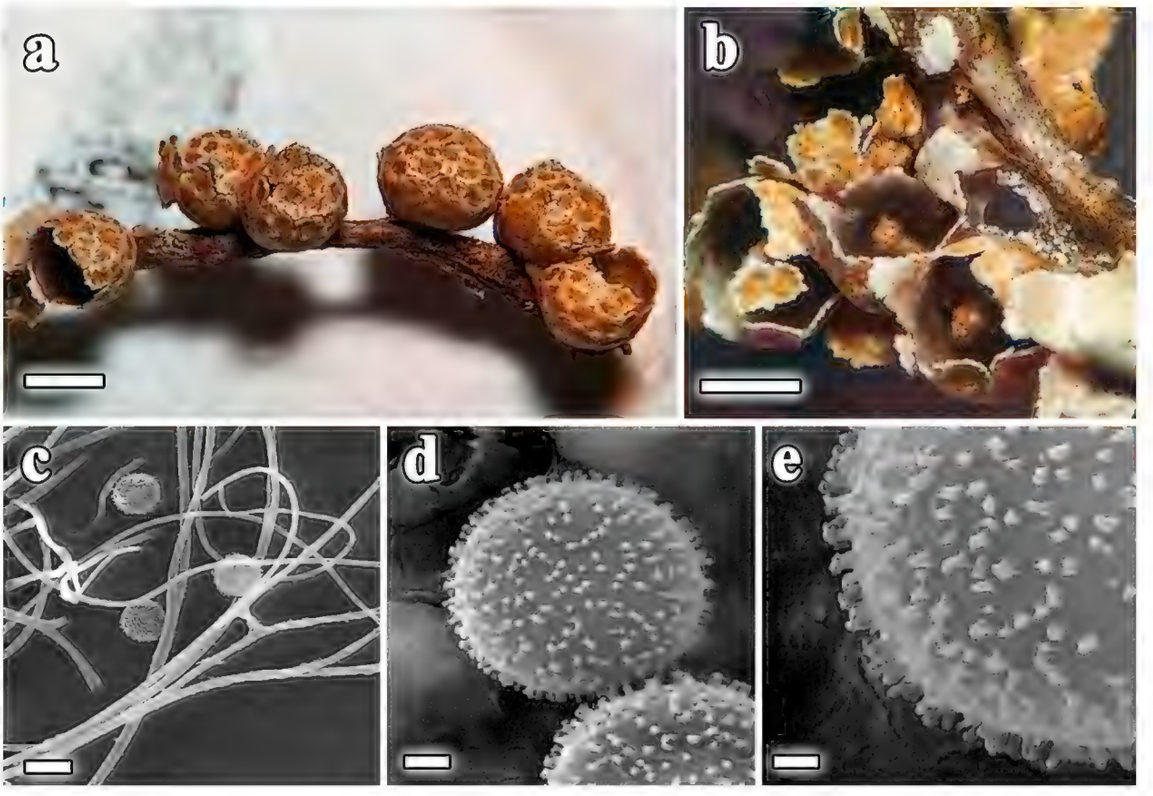

Fig. 8 *Lepidoderma peyerimhoffii* (AH 50503): a. Sporocarps; b. Peridium broken in polygonal plates; c. Capillitium; d. Spore; e. Spore ornamentation (detail).
Scale bars: a, b = 1 mm; c = 10 µm; d = 2 µm; e = 1 µm.

Lepidoderma peyerimhoffii Maire & Pinoy,
Bull. Soc. Hist. Nat. Afrique N. 17(1): 40. 1926 Fig. 8

The specimens studied were the typically reddish-brown grouped sporocarps. Peridium triple—an outer layer with brown lime scales that break into polygonal plates, white at the edges; an intermediate layer formed by white lime scales; and an inner layer as a hyaline, iridescent membrane. Pseudocolumella prominent, club-shaped, dark orange; sometimes with

scales resembling those of the peridium. Capillitium formed by dark brown threads that emerge radially from the pseudocolumella, threads ramified and with widenings. Spores dark violaceous-brown in transmitted light, globose to subglobose, 12–15 µm in diam., densely spinose.

Specimens examined: **FRANCE, Pyrénées-Atlantiques, Arette,** La Pierre San Martín ski resort, herbaceous debris, 26-v-2018, leg. M. Tapia 180526-008 (AH 50405); **SPAIN, Navarra, Isaba,** Belagua Valley, on shrub debris, 15-vi-2018, leg. M. Tapia 180615-008 (AH 50503).

Remarks—The *Lepidoderma peyerimhoffii* specimens collected for this work remind one of those studied by Moreno & al. (2018b), where photographs of the type were taken.

Meriderma echinulatum (Meyl.) Mar. Mey. & Poulain,
Myxomycètes 551. 2011 Fig. 9

The specimen comprises sessile or short-stalked sporocarps with ovoid sporothecas, 1–1.2 × 0.9–1.1 mm. Capillitium emerging as threads along the whole columella, dark brown, dense, with funnel-shaped ends attached to a piece of the peridium. Columella with a globose to swollen apex. Spores dark brown in transmitted light, globose to subglobose, 12–15 µm in diam,

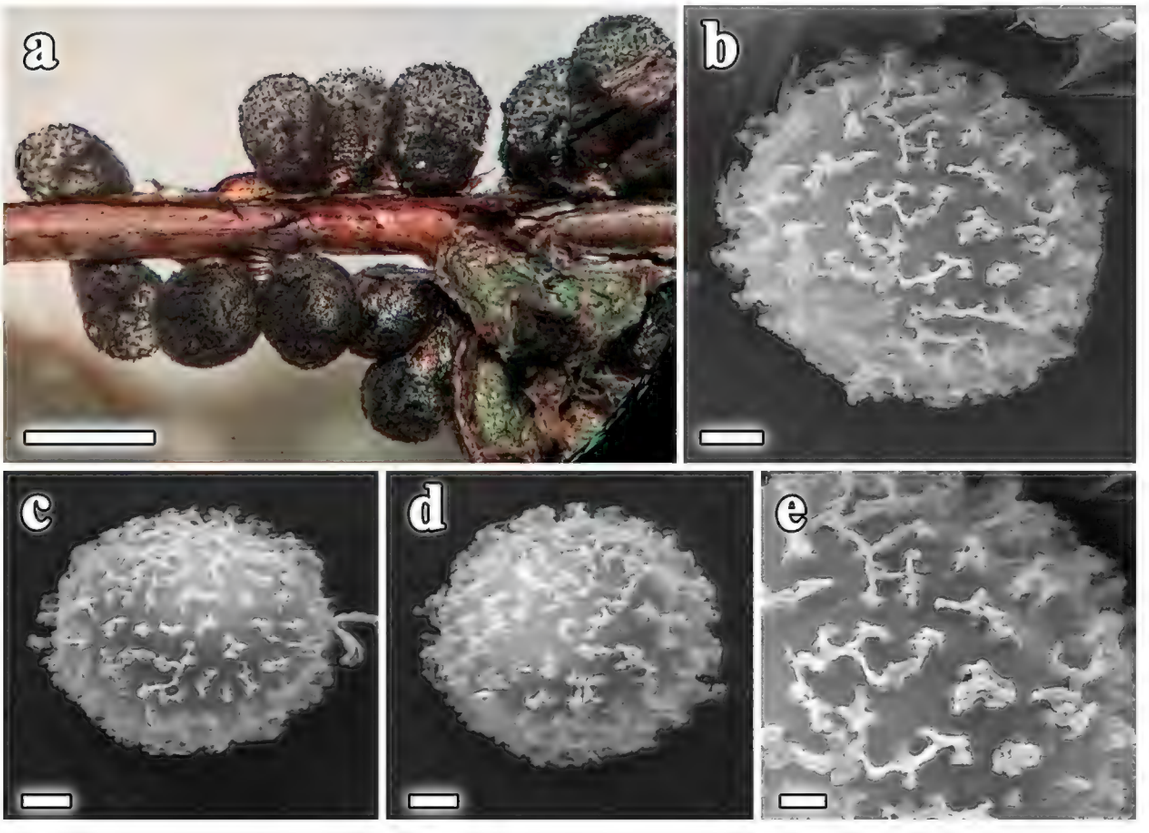

Fig. 9 *Meriderma echinulatum* (AH 50400): a. Sporocarps; b–d. Spores; e. Spore ornamentation (detail). Scale bars: a = 1 mm; b–d = 2 µm; e = 1 µm.

with prominent, irregular, and sinuous crests. The SEM confirmed the ornamentation showing solid walls lacking holes or pits) and with crests occasionally creating a small subreticulum with widened areas.

Specimen examined: **FRANCE, Pyrénées-Atlantiques, Arette**, La Pierre San Martín ski resort, herbaceous debris, 22-v-2018, leg. M. Tapia 180522-018P1 (AH 50400).

Remarks—*Meriderma echinulatum* is well delimited by its spore ornamentation. The lectotype, studied by Moreno & al. (2002), shows an ornamentation that matches with the SEM micrographs of the current study as well as with Meylan's definition (Meylan 1932). Janik & Ronikier's (2016) spores of *M. echinulatum* had a denser and subreticulate ornamentation.

Physarum vernum Sommerf., in Fries, Syst. Mycol. 3(1): 146. 1829 Fig. 10

The specimens are developed in the form of long plasmodiocarps. Peridium double, consisting of an inner membrane covered by an outer layer of white calcium carbonate. Capillitium abundant, white, with fusiform to subglobose nodules. Spores dark violaceous-brown by transmitted light, globose to subglobose, 11–13 µm diam., spiny.

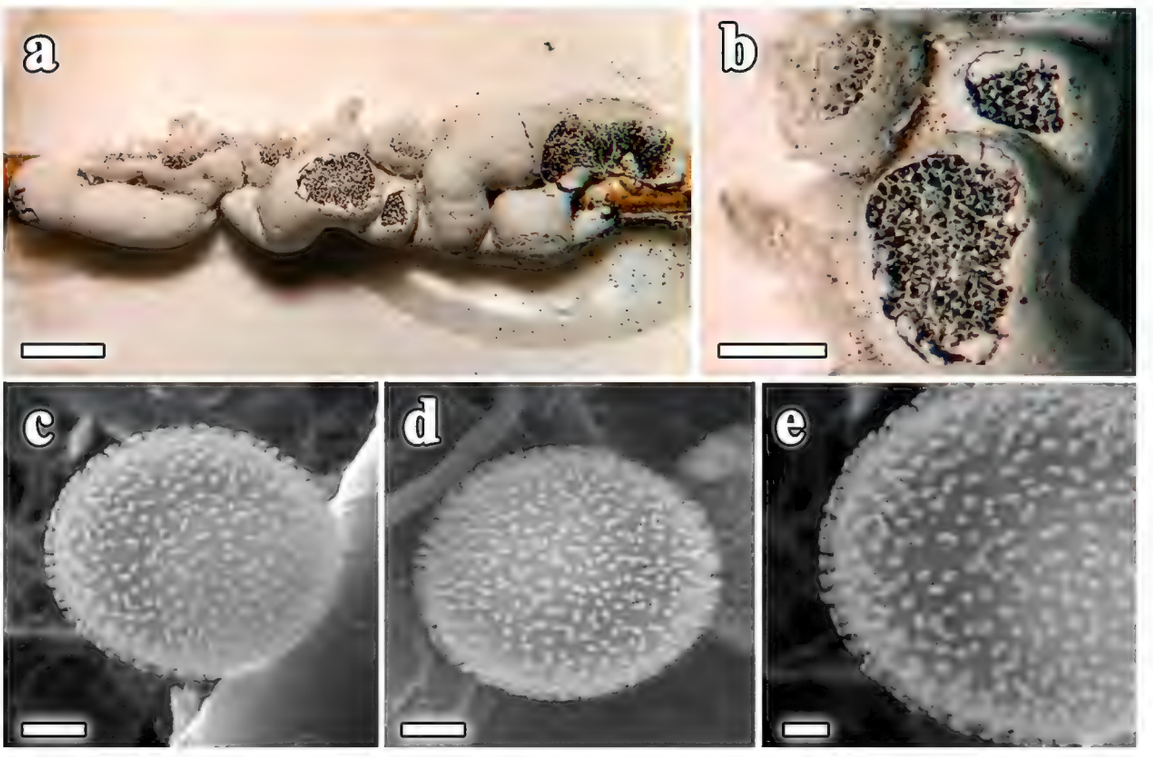

Fig. 10 *Physarum vernum* (AH 50401):
a. Sporocarps; b. Detail of the capillitium; c, d. Spores; e. Spore ornamentation (detail).
Scale bars: a = 1 mm; b = 0.5 mm; c, d. = 2 µm; e = 1 µm.

Specimens examined: **SPAIN, Navarra, Isaba,** Belagua Valley, on soil, 8–v–2018, leg. M. Tapia 180508–022 (AH 50399); on *Genista hispanica* subsp. *occidentalis* Rouy, 8–v–2018, leg. M. Tapia 180508–044 (AH 50409); herbaceous debris, 8–v–2018, leg. M. Tapia 180508–037 (AH 50411); leg. M. Tapia 180508–018 (AH 50412); 10–vi–2018, leg. M. Tapia 180610–003 (AH 50498); **FRANCE, Pyrénées-Atlantiques, Arette,** La Pierre San Martín ski resort, herbaceous debris, 26–v–2018, leg. M. Tapia 180526–007 (AH 50401); leg. M. Tapia 180526–021 (AH 50406).

Remarks—A detailed description of *Physarum vernum* can be found in Moreno & al. (2018a). This species is widely distributed throughout the Northern Hemisphere (https://discoverlife.org).

Acknowledgments

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